KIMBROUGH ARMY COMMUNITY HOSPITAL
FT. GEORGE G. MEADE, MARYLAND
ENERGY ENGINEERING ANALYSIS PROGRAM

FOR

DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT CORPS OF ENGINEERS

FINAL REPORT

DECEMBER 1988

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A. EXECUTIVE SUMMARY

I. INTRODUCTION

PURPOSE

Mueller Associates, Inc. (MAI) was retained by the Baltimore District of Army Corps of Engineers in September of 1985 to perform energy conservation services at Fort George G. Meade, Maryland. The contract included studies of the following buildings:

- o #2480 - Kimbrough Army Community Hospital (KACH)
- o #8472 - Dental Clinic
- o #2481 - Barracks
- o #2484 - Medical Supply Warehouse

The Scope of this study included the following objectives:

- o Perform a complete energy audit and analysis of the entire Kimbrough Army Community Hospital including the attached Outpatient Clinic.
- o Investigate the feasibility of an Energy Monitoring and Control System (EMCS) for the hospital.
- o Investigate exhaust systems in the Dental Clinic.
- o Investigate window replacement and chilled water temperature of the Barracks.
- o Investigate the feasibility of infra-red heaters, loading dock door seals, and air stratification in the Medical Supply Warehouse.
- o Identify all energy conservation opportunities, including low cost/no cost items and perform complete evaluations of each.
- o Prepare programming documentation for all energy conservation investment program projects including DD Form 1391, a life cycle cost analysis summary sheet with backup calculations, and a Project Development Brochure.
- o Prepare implementation documentation for all justifiable energy conservation opportunities.
- o List and prioritize all recommended energy conservation opportunities.

APPROACH

Methodology followed to accomplish this study consisted of the following steps:

1) Review the Scope of Work and prepare a detailed task plan.
2) Obtain and review available architectural, mechanical, and electrical drawings for all buildings in the project scope including drawings for changes which have occurred since the original building occupancies.
3) Review existing documents as listed below:
   - o Kimbrough Hospital Energy Audit, FESA-T-2106, September 1981
   - o Dept. of the Army letter DAEN-ZCF-U, ECIP Guidance, 4 March 1985
   - o Army TM-5-800-2, Cost Estimates Military Construction, June 1985
   - o U.S. Army Corps of Engineers, HNDSP-84-076-ED-ME, January 1984
   - o Army Regulation 415-15, Military Construction, Army Program Development, 1 January 1984
   - o TM-5-785, Engineering Weather Data, 1 July 1978
   - o Army Regulation 5-4, Dept. of the Army Productivity Improvement Program, 1 August 1982
   - o Army Regulation 415-17, Cost Estimating for Military Programming, 15 February 1980
   - o Army Regulation 415-20, Project Development and Design Approval, 28 March 1974
   - o Army Facilities Energy Plan, 9 December 1984
   - o TM 5-838-2, Army Health Facility Design, March 1981
   - o DOD 4270.1-M, Construction Criteria, 15 December 1983
4) Surveys of the four buildings were conducted by engineers, control specialists, technical specialists, and a member of the architectural team. The computer modeling specialist was also included to familiarize her with the characteristics of the hospital building. The detailed room surveys and air flow measuring was

conducted over a period of 4 months by a technical specialist. Air flow measurement of many ducts in the Hospital and Dental Clinic could not be immediately accomplished because of asbestos insulation. This hazardous material had to be spot-removed which caused considerable delay in the measurement process.

5) During the detailed room surveys, the technician noted any deleterious modifications or maintenance procedures. These are listed under OPERATIONAL AND MAINTENANCE RECOMMENDATIONS.

6) From the document review and survey information, the Hospital Building, including Clinic Addition, was modeled using the energy analysis program DOE2.1b in a baseline condition. It was assumed for the baseline analysis that all systems were operating properly with measured mass flows rather than "as modified" or inoperative.

7) A list of potential energy conservation opportunities (ECO's) was developed. These were preliminarily analyzed to determine which had potential for favorable savings investment ratio. The selected ECO's which involved relatively large amounts of energy savings for the hospital were analyzed with the DOE 2.1b program to determine energy savings as compared to the baseline model. Other relatively minor hospital ECO's and those ECO's which were for other buildings were analyzed by hand calculations. The computer program uses field survey data, annual weather data profiles, occupancy schedules, building construction features, and HVAC system design information in an hour-by-hour mode to model the thermal features of the building.

8) Prepare a comprehensive report to meet all objectives of the detailed work scope. Main elements of the report include listing of ECO's life cycle cost data, room summary table, deficiencies and recommendations, and an appendix of supporting data.

DESCRIPTION OF WORK ACCOMPLISHED

The architectural/engineering team reviewed as-built drawings, conducted surveys of the building envelopes and HVAC systems and studied results of prior energy conservation studies and existing operational procedures. A comprehensive report has been prepared which documents the work accomplished, the results and recommendations, field survey information, and data analysis.

At the conclusion of the survey phase, an initial list of 41 ECO's was prepared for preliminary consideration. Of this initial list, 11 were culled out because it was apparent that they would not save energy or the amortization period would be very long. The balance of the ECO's were analyzed either by DOE 2.1b or by hand calculation methods.

Hospital (Building No. 2480)

Each of the 728 rooms of the KACH was surveyed in detail. Air flows in each main supply and exhaust system was measured along with a survey of the configuration and current control operation. Where systems or control configuration did not agree with original or retrodesign documents, such modifications were noted.

Survey information, HVAC requirements, and load calculations were compiled in a spreadsheet table for each of the hospital rooms.

Section A.II contains the baseline energy consumption for the Hospital Building as calculated by program DOE 2.1b. Current energy tariffs were obtained from the Project Manager at Ft. Meade. These were escalated in accordance with ECIP Guidance to calculate the energy costs for fiscal years '86, '87, '88, and '89.

The hospital building was evaluated for feasibility of an EMCS. Mechanical, utility, and control systems were surveyed and input/output tables prepared. This information was used to establish a system cost for use in the life cycle cost analysis (LCCA).

Barracks (Building No. 2481)

Annex D of the Scope of Work specifies investigation of window replacement and chilled water temperature in this building. Review of the Barracks drawings and the on-site survey revealed that cooling is provided by an air cooled multi-zone unit and not by chilled water. Also, the windows in this building were replaced approximately two years ago. Consequently, these two aspects of the Barracks were not investigated.

There is, however, a problem with the refrigeration system of the air handling unit. Something periodically causes the system to shut down. It could be a dirty coil, low refrigerant charge, faulty control sensor, or a combination of related malfunctions.

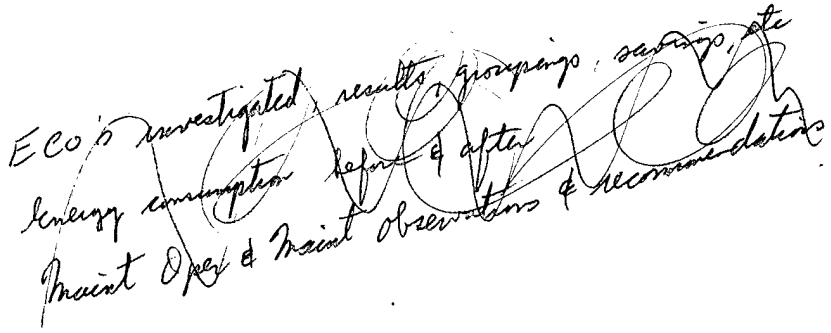
Dental Clinic (Building No. 8472)

Investigation of the ventilation systems in the Dental Clinic was conducted in a fashion similar to the procedure used for the Hospital. The air balance of each room was surveyed and the flow of air moving equipment was measured. Drive belts on 3 of the 4 exhaust fans are broken which results in an exhaust system with only 23 percent of design capacity. Also, the multi-zone air handling unit is supplying only 84 percent of design capacity. The compounded effect is a ventilation rate of less than one air change per hour.

Medical Supply Warehouse (Building No. 2484)

The simple function and low population of the warehouse building does not warrant a sophisticated environmental control system. No cooling is provided and the heating system dictated by the high bays consists of downblow steam unit heaters. Destratification fans have been proposed by Annex D as a possible energy saver, but the existing downblow unit heaters already provide the same effect. Destratification fans are not as effective as infra-red heaters because they homogenize temperature in the space, low and high.

Two large roll-up doors allow significant infiltration while trucks are unloading. This situation can be improved by installation of truck mating door seals. Heating energy consumption can be significantly reduced by a gas-fired infra-red heating system.



II. BASELINE ENERGY CONSUMPTION

INTRODUCTION

In order to determine the viability and applicability of various Energy Conservation Opportunities(ECOs) it is often first necessary to establish the baseline energy consumption of the building or building portion being analyzed.

This information may be best determined from actual measured energy consumption or utility records. This type of information was not available for the buildings being studied; however base wide energy consumption and cost data was available with which to compare the calculated baseline values and calculate energy costs.

Baseline energy consumption was calculated using the Department of Energy, hourly building energy consumption simulation program DOE-2.1B. DOE-2.1B is a public domain program which is widely used for this type of computation and provides an acceptable estimation of baseline energy use with which to compare ECOs. This simulation requires the description of building construction components, energy consuming systems, and occupational and operational profiles. This data is used to model the building, on an hour by hour basis, by the program using weather data for the building location.

Baseline building energy consumption estimation is often necessary due to the size and complexity of buildings, their current operation and the type of ECOs which are to be considered. Such a baseline was necessary for most of the ECOs considered for KACH.

A portion of the ECOs were calculated without the use of the DOE-2 program since no increase in accuracy would have been gained by its use and, in many cases, the magnitude of energy saved would not be revealed in the calculations. This is true of the ECOs associated with the other buildings surveyed; Dental Clinic, Medical Supply Warehouse, and Barracks. It was possible to calculate savings for these ECOs without the need for whole building energy consumption estimation. For this reason it was not necessary to calculate baseline energy usage for these buildings.

KIMBROUGH ARMY COMMUNITY HOSPITAL BASELINE ENERGY CONSUMPTION

Baseline energy consumption for the main hospital building and out-patient clinic addition is provided. This energy consumption is expressed in million Btu (MBtu) for both site and source energy components. Site and source energy and cost conversion factors are included in Table A-1. These factors apply to all study buildings.

Table A-1 PROJECT CONVERSION FACTORS

Energy Type	Units	$/Unit	Site Energy Btu/Unit	Source Energy Btu/Unit	Source Energy $/MBtu
Electricity					
Winter	kWh	$0.0395	3,413	11,600	$3.405
Summer	kWh	$0.0587	3,413	11,600	$5.060
Average (weighted)	kWh	$0.0459	3,413	11,600	$3.957
Natural Gas	Therm	$0.4229	100,000	100,000	$4.229
No. 2 Fuel Oil	Gal.	$0.82	138,700	138,700	$5.91

Total site energy used is reported by site energy type; steam, electricity, and natural gas for each category of use. Refer to Table A-2 and Figure A-1. Costs of fuel types were provided by Ft. Meade.

Source energy consumption is also reported. Source energy includes that energy expended in the production or distribution of energy prior to its consumption at its end use. Central steam (site energy) is provided to the hospital as a utility source. This central steam is generated using No.2 Distillate Oil; the numerical computation for calculating includes the conversion efficiency of the steam plant. Electricity consumed at the building, that is, that which would be measured by a conventional utility meter, is referred to as the site electrical consumption. Source energy consumption includes the amount of energy required to generate and distribute electricity from the utility plant. Natural gas site and source energy are considered equal for our analysis. Source energy consumption by fuel type No.2 Oil,

Electricity, and Natural Gas is shown in Table A-3 and Figures A-2 and 3.

The annual values presented in the preceding tables and figures were calculated using the DOE-2.1B program. Monthly site energy calculated is shown in Table A-4 and Figure A-4.

Table A-2 KIMBROUGH ARMY COMMUNITY HOSPITAL
Baseline Site Energy Consumption

MAIN BUILDING	Site MBtu by Fuel Type			
Category Of Use	Fuel Oil	Electricity	Natural Gas	Total
Space Heat	23,871	0	0	23,871
Space Cool	0	1,381	0	1,381
Hvac Aux.	0	2,455	0	2,455
DHW	1,194	0	0	1,194
Lights	0	3,178	0	3,178
Elev.	0	78	0	78
Misc. Equip.	0	2,922	1,459	4,381
Total	25,065	10,014	1,459	36,538

HOSPITAL ADDITION	Site MBtu by Fuel Type			
Category Of Use	Fuel Oil	Electricity	Natural Gas	Total
Space Heat	5,880	0	0	5,880
Space Cool	0	912	0	912
Hvac Aux.	0	2,095	0	2,095
DHW	269	0	0	269
Lights	0	1,246	0	1,246
Elev.	0	0	0	0
Misc. Equip.	0	261	0	261
Total	6,149	4,513	0	10,662

TOTAL BUILDING	Site MBtu by Fuel Type			
Category Of Use	Fuel Oil	Electricity	Natural Gas	Total
Space Heat	29,751	0	0	29,751
Space Cool	0	2,293	0	2,293
Hvac Aux.	0	4,550	0	4,550
DHW	1,463	0	0	1,463
Lights	0	4,424	0	4,424
Elev.	0	78	0	78
Misc. Equip.	0	3,183	1,459	4,642
Total	31,214	14,527	1,459	47,200

Notes:
1. Baseline values were calculated using the DOE-2.1B program.
2. Energy consumption is expressed in MBtu (Million Btu).
3. Actual metered data not available. Usage profiles were recorded during building survey
4. Weather Data; DOE Typical Meterlogical Data for Baltimore, MD. Annual Cooling Degree Days 1039. Annual Heating Degree Days 4733
5. Fuel Cost Estimates are based on actual 1986 fuel costs.

Figure A-1 BASELINE ENERGY CONSUMPTION

(Kimbrough Army Community Hospital SITE MBtu by End Use)

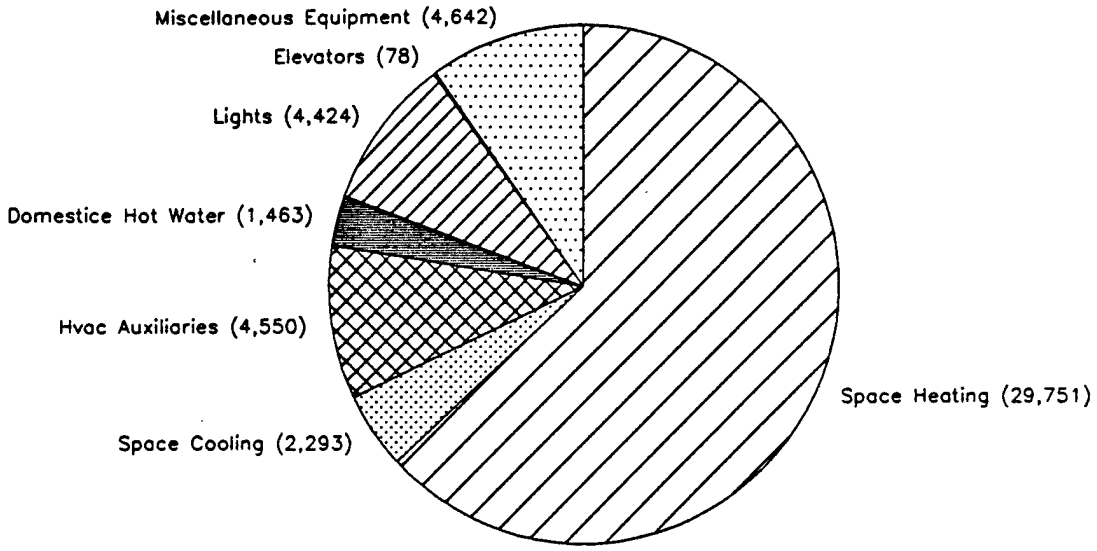


Figure A-2 BASELINE ENERGY CONSUMPTION

(Kimbrough Army Community Hospital SOURCE MBtu by End Use)

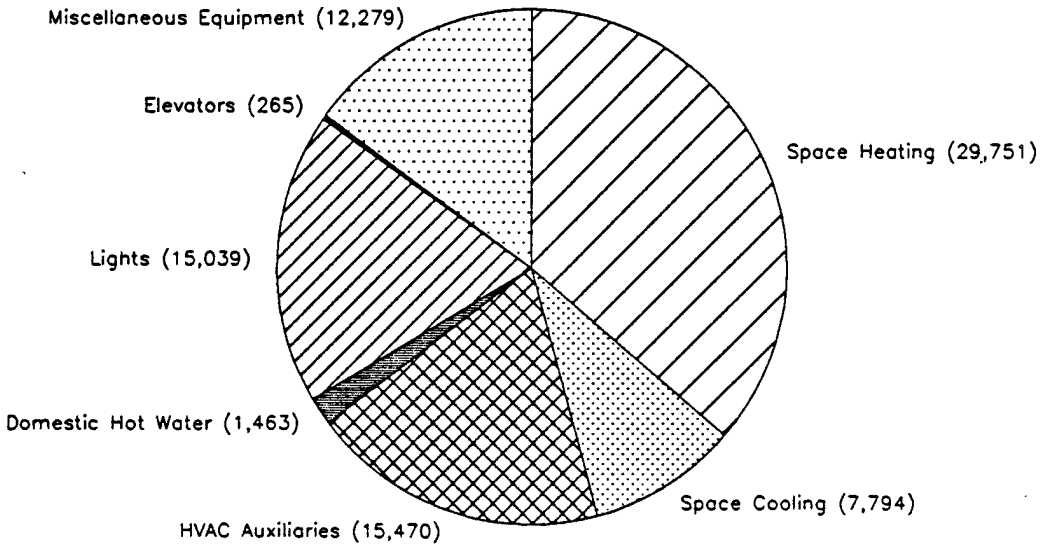


Table A-3 KIMBROUGH ARMY COMMUNITY HOSPITAL
Baseline Source Energy Consumption

Category Of Use	SOURCE MBtu by Fuel Type Fuel Oil	Electricity	Natural Gas	Total
Space Heat	29,751	0	0	29,751
Space Cool	0	7,794	0	7,794
Hvac Aux.	0	15,470	0	15,470
DHW	1,463	0	0	1,463
Lights	0	15,039	0	15,039
Elev.	0	265	0	265
Misc. Equip.	0	10,820	1,459	12,279
Source Energy (Mbtu)	31,214	49,388	1,459	82,061

SOURCE Consumption (Conventional Units) by Fuel Type	Fuel Oil	Electricity	Natural Gas	Total
Conversion Factors				
Conventional UNIT	Gal	kWh	Therm	
Source Btu/Unit	138,700	11,600	100,000	
Fuel Cost ($/Unit)	$0.8200	$0.0459	$0.4229	
Fuel Oil (Gal)	225,050			
Electricity (kWh)		4,257,567		
Natural Gas (Therm)			14,590	
Annual Energy Cost	$184,541	$195,422	$6,170	$386,133

Notes:
1. Baseline values were calculated using the DOE-2.1B program.
2. Actual metered data not available. Usage profiles were recorded during building survey
3. Weather Data; DOE Typical Meterlogical Data for Baltimore, MD. Annual Cooling Degree Days 1039. Annual Heating Degree Days 4733
4. Fuel Cost Estimates are based on actual 1986 fuel costs.

Table A-4 KIMBROUGH ARMY COMMUNITY HOSPITAL
Monthly Site Energy Consumption

	MAIN BUILDING			ADDITION		HOSPITAL TOTAL		
Month	Fuel Oil	Elec	Nat Gas	Fuel Oil	Elec	Fuel Oil	Elec.	Nat Gas
Jan	4,894	723	124	889	298	5,783	1,021	124
Feb	4,059	654	112	754	269	4,814	923	112
Mar	3,151	735	124	677	302	3,829	1,037	124
Apr	1,641	713	120	429	287	2,070	1,000	120
May	1,314	920	124	619	462	1,932	1,382	124
Jun	588	1,001	120	299	493	887	1,493	120
Jul	443	1,080	124	220	523	663	1,603	124
Aug	510	1,068	124	259	524	769	1,592	124
Sep	741	952	120	384	474	1,125	1,426	120
Oct	1,013	747	124	258	298	1,271	1,044	124
Nov	2,449	701	120	556	287	3,006	988	120
Dec	4,260	718	124	806	295	5,066	1,013	124
Total	25,065	10,012	1,459	6,149	4,513	31,214	14,525	1,459

Note: All values represent MBtu (Million Btu).
1. Baseline values were calculated using the DOE-2.1B program.
2. Actual metered data not available. Usage profiles were recorded during building survey
3. Weather Data; DOE Typical Meterlogical Data for Baltimore, MD. Annual Cooling Degree Days 1039. Annual Heating Degree Days 4733
4. Fuel Cost Estimates are based on actual 1986 fuel costs.

Figure A-3 BASELINE ENERGY CONSUMPTION

(Kimbrough Army Community Hospital SOURCE MBtu by Fuel Type)

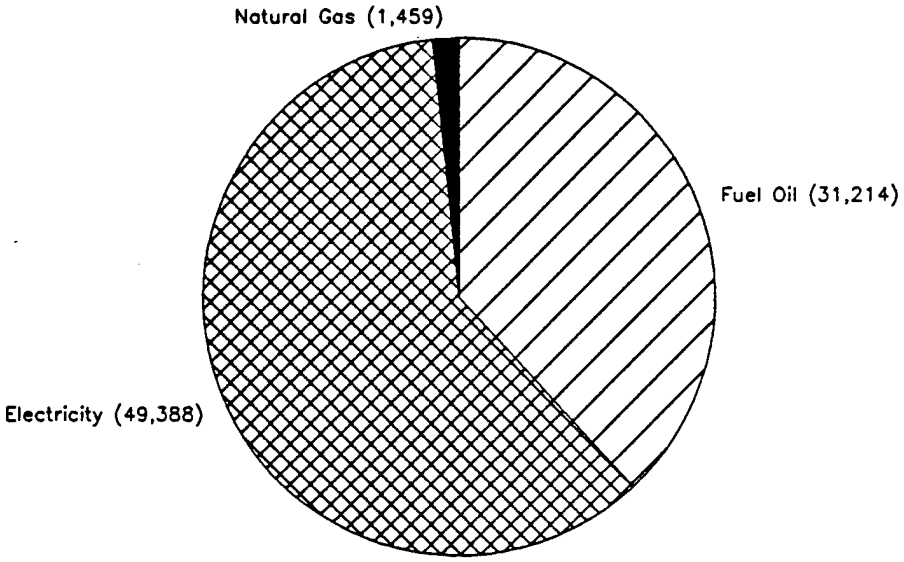


Figure A-4 ANNUAL ENERGY CONSUMPTION

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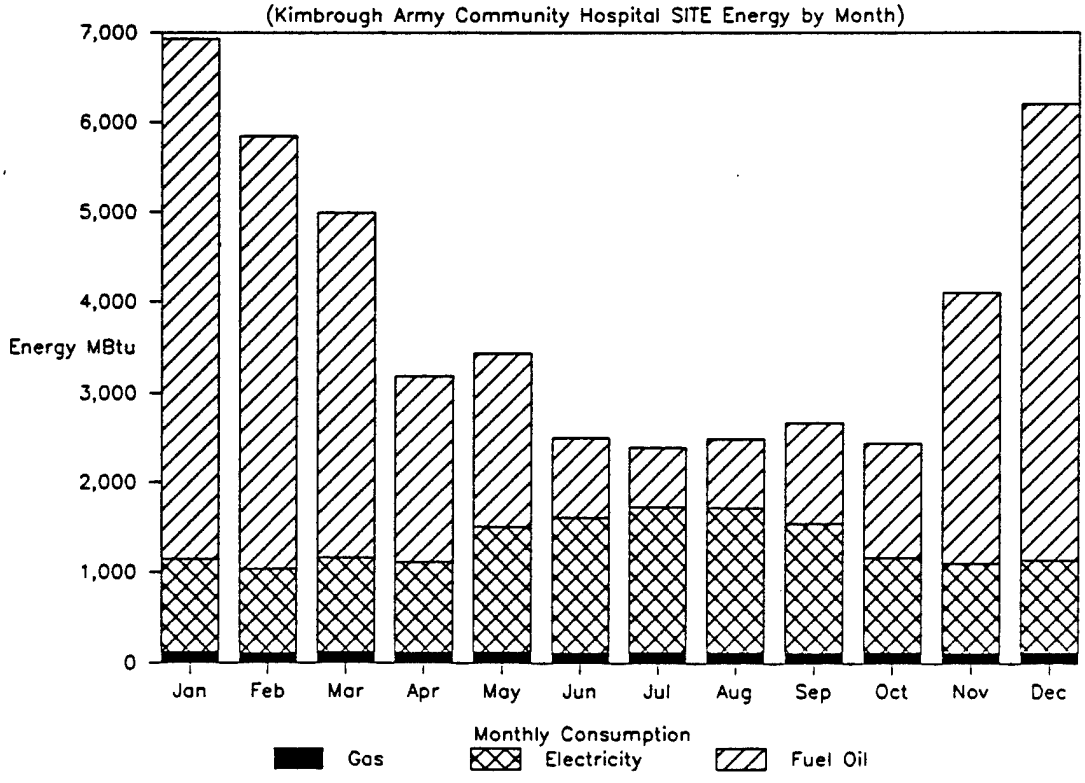
(Kimbrough Army Community Hospital SITE Energy by Month)



III. ENERGY CONSERVATION ANALYSIS

ECO's Investigated

During the preliminary stages of this EEAP Study building drawings were reviewed and a detailed inspection of building systems were made. Building operating personnel and building occupants were interviewed to determine system operation and building occupancy schedules and procedures.

Based on the understanding of the physical and operational nature of the building and its systems a number of ECO's were analyzed or considered for analysis.

A list of those ECO's is provided as Table A-5.

ECO's Recommended

In order to determine ECO cost effectiveness energy and operational costs were calculated, energy consumption was estimated and life-cycle costing techniques were used. Energy savings calculations were made using a variety of methods including; simple hand calculations, bin-temperature analysis and hourly building energy use programs.

Those ECO's determined to be cost effective are listed in Table A-6. The ECO's are ranked by Savings-to-Investment Ratio (SIR) with highest SIR being the most attractive investment.

ECIP Project

The ECO's found to be cost effective were placed in categories for funding. Following review of implementation costs and cost effectiveness parameters, and consideration by the Army Corp of Engineers and the using facility; ECO's were placed in categories for funding. Of those ECO's recommended, only one was selected for consideration as an Energy Conservation Investment Program. This ECO and its cost parameters are shown in Table A-7.

Other Energy Conservation Projects

All other ECO's have been included in energy conversation projects under the following programs.

- Quick Return on Investment Program (QRIP)
- Productivity Enhancing Capital Investment Program (PECIP)
- or, Low Cost/No Cost (LC/NC) Projects.

A listing of projects to be included in these programs is shown in Table A-8.

TABLE A-5 ECO'S INVESTIGATED

#	ECO'S INVESTIGATED (Considered and/or Analyzed)	DETERMINATION
1	Provide Chiller For X-Ray Area	(1)
2	Provide Chiller For Laboratory & X-Ray	(1)
3	O/A Unit to Serve Dining Hall	Recommended
4	VAV System to Serve Main Admin Area	Not Feasible
5	Unoccupied Mode on C-Wing Air Systems	Recommended
6	Double Bundle Chiller/Heat Recovery	(1)
7	Double Bundle Chiller with Variable Air Volume System	(1)
8	Cogeneration System	(1)
9	Night-Cycle-On ACU1-M	Recommended
10	Dual Duct VAV in Hospital Addition	Recommended
11	Interconnect All Chillers	Recommended
12	Variable-Flow Primary CHW Pumps	Recommended
13	Variable-Flow Secondary CHW Pumps	Not Feasible
14	Kitchen Ventilation Improvements	Recommended
15	Unoccupied Mode at ACU1-A	Recommended
16	Preheat DHW with Freezer Condenser	(1)
17	Exhaust Heat Recovery On ACU2-M	Recommended
18	Relamp with Energy Efficient Lighting	Recommended
19	Exhaust Hood For Blood Still	(1)
20	Eliminate Publication Room Exhaust	Recommended
21	Control Valve At Dish Drying Coil	Recommended
22	Outdoor Air Make-Up At Steam Pressure Reducing Station	Recommended
23	Programmable Timer On Kitchen Ventilation	Recommended
24	Gas-Fired Infra-Red Heating For Medical Warehouse	Recommended
25	Night Cycle on ACU4-M	Recommended
26	Night Cycle on ACU3-M	Recommended
27	Programmable Timers On Building Exhaust	(1)
28	Insulation of Steam Pressure Reducing Station	Recommended
29	Readjust Fan Supplies	(1)
30	Insulate Precooler Duct	(1)
31	Night Cycle For ACU2-A AND ACU3-A	Recommended
32	Airlock for Emergency Room Entrance	Not Feasible
33	Replace Stairway Glass with Insulated Panels	Not Feasible
34	Insulate Dental Clinic Walls	Not Feasible
35	Vestibule At Kitchen Loading Dock	Not Feasible
36	Upgrade Hospital Roof Insulation	Recommended
37	Insulate Barracks Walls	Recommended
38	Truck Door Seals For Warehouse	Not Feasible
39	Reduce Heating In Warehouse	(1)
40	Tower Multi-Speed Fan, Incremental cost analysis	Recommended
41	Energy Efficient Motor	Not Feasible
EMCS	Automation of (5,9,15,23,25,26,31)	(1)

Note (1): Did Not Pass Preliminary Analysis

Table A-6

RECOMMENDED ENERGY CONSERVATION MEASURES (SIR PRIORITY)

ECO #	Description	Instal. Cost ($)	Annual Source Energy Savings (MBtu)				Economic Life (yrs)	Annual Savings ($) (1)	SIR	Amort. Period (yrs) (2)	Analysis Date	Funding Program	Year of Program
			Fuel Oil	Nat. Gas	Electric.	Total							
20	Eliminate Publication Room Exhaust	25	101		82	183	n/a	$922	596.56	0.03	August 86	LC\NC	March 90
9	Night-Cycle-On ACU1-M	2,220	1,999		850	2,849	15	$15,153	78.40	0.15	August 86	QRIP	January 90
25	Night Cycle on ACU4-M	1,800	1,329		391	1,720	15	$9,377	60.72	0.19	August 86	QRIP	January 90
21	Control Valve At Dish Drying Coil	924	446			446	25	$2,659	52.54	0.35	August 86	LC\NC	March 90
23	Programmable Timer On Kit. Ventil'n	2,800	1,336		759	2,095	15	$10,846	43.93	0.26	August 86	QRIP	January 90
22	O/A Make-Up At Steam P.R.Station	3,100	1,776		156	1,932	15	$11,118	42.89	0.28	August 86	PECIP-1	March 90
28	Insulation of Steam P.R. Station	1,540	451			451	25	$2,642	31.57	0.59	August 86	PECIP-1	March 90
18	Relamp W/Energy Efficient Lighting	9	(0.18)		0.99	0.80	25	$12.92	16.29	0.70	August 86	LC\NC	March 90
26	Night Cycle on ACU3-M	8,900	1,239		265	1,504	15	$8,301	10.99	1.08	August 86	QRIP	January 90
31	Night Cycle For ACU2-A AND ACU3-A	24,500	2,499		2,210	4,709	15	$23,463	10.58	1.05	August 86	QRIP	January 90
14	Kitchen Ventilation Improvements	61,500	4,528		201	4,729	25	$27,065	8.04	2.29	August 86	PECIP-1	March 90
15	Unoccupied Mode at ACU1-A	14,300	656		622	1,279	15	$6,316	4.86	2.28	August 86	QRIP	January 90
17	Exhaust Heat Recovery On ACU2-M	32,400	1,585		(347)	1,238	25	$6,774	4.35	4.81	August 86	PECIP-1	March 90
36	Upgrade Hospital Roof Insulation	56,047	1,645		136	1,781	25	$10,261	3.30	5.50	August 86	LC\NC	March 90
5	Unocc.Mode on C-Wing Air Systems	34,500	854		1,125	1,979	15	$9,269	2.91	3.75	August 86	QRIP	January 90
11	Interconnect All Chillers	52,800			4,804	4,804	25	$18,366	2.89	4.26	August 86	PECIP-2	May 90
3	O/A Unit to Serve Dining Hall	23,800	727		265	992	15	$4,619	2.32	5.19	August 86	PECIP-1	March 90
24	Gas-Fired IR Htg. For Medical Whse.	26,000	1,686	(1,223)		463	15	$4,544	2.19	5.76	August 86	LC\NC	March 90
37	Insulate Barracks Walls	15,900	250		10	260	25	$1,518	1.73	10.55	August 86	PECIP-2	May 90
10	Dual Duct VAV in Hospital Addition	251,000	3,253		4,508	7,761	15	$30,138	1.33	8.38	August 86	ECIP	August 91
12	Variable-Flow Primary CHW Pumps	27,900			910	910	25	$2,991	1.33	9.39	August 86	PECIP-1	March 90
40	Tower Multi-Speed Fan ($ Increment)	3,600			93	93	25	$312	1.08	11.62	August 86	LC\NC	March 90
	Total for all projects (3)	$648,465	22,184	(1,223)	19,326	40,287		$200,000 Approx.					

NOTES:(1) ECIP LCCA Item 4: First year dollar savings. Negative savings indicate yearly cost.

(2) Simple payback period

(3) Resulting figures consider synergism of energy conservation measures, and they may not be the algrebraic sum of individual projects.

Table A-7

ENERGY CONSERVATION INVESTMENT PROJECTS (ECIP)

ECO #	Description	Instal. Cost ($)	Annual Energy Savings (MBtu) Fuel Oil	Nat. Gas	Electric.	Total	Economic Life (yrs)	Annual Savings ($) (3)	SIR	Amort. Period (yrs) (2)	Analysis Date	Funding Program	Year of Program
ECIP: ENERGY CONSERVATION INVESTMENT PROGRAM													
10	Dual Duct VAV in Hospital Addition	251,000	3,253		4,508	7,761	15	$30,138	1.33	8.38	August 86	ECIP	August 91
		$251,000				7,761		$30,138		8.38			

NOTES:(1) ECIP LCCA Item 4: First year dollar savings (Negative savings indicate yearly cost)

(2) Simple payback period

Table A-8

ENERGY CONSERVATION PROJECTS

ECO #	Description	Instal. Cost ($)	Energy Savings (MBtu)	Economic Life (yrs)	Annual Savings ($) (1)	SIR	Amort. Period (yrs) (2)
QRIP:	QUICK RETURN ON INVESTMENT PROGRAM						
5	Unocc.Mode on C-Wing Air Systems	$34,500	1,979	15	$9,269	2.91	3.75
9	Night-Cycle-On ACU1-M	$2,220	2,849	15	$15,153	78.40	0.15
15	Unoccupied Mode at ACU1-A	$14,300	1,279	15	$6,316	4.86	2.28
23	Programmable Timer On Kit. Ventil'n	$2,800	2,094	15	$10,846	43.93	0.26
25	Night Cycle on ACU4-M	$1,800	1,720	15	$9,377	60.72	0.19
26	Night Cycle on ACU3-M	$8,900	1,504	15	$8,444	10.99	1.08
31	Night Cycle For ACU2-A AND ACU3-A	$24,500	4,709	15	$23,463	10.58	1.05
	PACKAGE TOTAL (NOTE 3.)	$89,020	15,375	15	$79,725	10.18	1.12
PECIP-1:	PRODUCTIVITY ENHANCING CAPITAL INVESTMENT PROGRAM (Package 1)						
3	O/A Unit to Serve Dining Hall	$23,800	992	15	$4,619	2.32	5.19
12	Variable-Flow Primary CHW Pumps	$27,900	910	25	$2,991	1.33	9.39
14	Kitchen Ventilation Improvements	$61,500	4,729	25	$27,065	8.04	2.29
17	Exhaust Heat Recovery On ACU2-M	$32,400	1,238	25	$6,774	4.35	4.81
22	O/A Make-Up At Steam P.R.Station	$3,100	1,932	15	$11,118	42.89	0.28
28	Insulation of Steam P.R. Station	$1,540	451	25	$2,642	31.57	0.59
	PACKAGE TOTAL (NOTE 3.)	$153,817	10,252	25	$55,221	6.53	2.80
PECIP-2:	PRODUCTIVITY ENHANCING CAPITAL INVESTMENT PROGRAM (Package 2)						
11	Interconnect All Chillers	$52,800	4,804	25	$18,366	2.89	4.26
37	Insulate Barracks Walls	$15,900	260	25	$1,518	1.73	10.55
	PACKAGE TOTAL (NOTE 3.)	$68,023	5,064	25	$19,885	3.44	3.71
LOW COST / NO COST MODIFICATIONS							
18	Relamp W/Energy Efficient Lighting	$8.94	0.8	25	$12.92	16.29	0.70
20	Eliminate Publication Room Exhaust	$25	183	n/a	$922	596.56	0.03
21	Control Valve At Dish Drying Coil	$924	446	25	$2,659	52.54	0.35
24	Gas-Fired IR Htg. For Medical Whse.	$26,000	463	15	$4,544	2.19	5.76
36	Upgrade Hospital Roof Insulation	$56,047	1,781	25	$10,261	3.30	5.50
40	Tower Multi-Speed Fan ($ Increment)	$3,600	93	25	$312	1.08	11.62
	PACKAGE TOTAL (NOTE 3&4) Approximate	$86,605	2,966		$18,710		4.66

NOTES:(1) ECIP LCCA Item 4: First year dollar savings
(Negative savings indicate yearly cost)

(2) Simple payback period

(3) Package totals are the resulting totals considering synergistic effects if any. Totals may not be the algebraic sum of component projects.

(4) Low Cost No Cost Modifications are not funded as one package.

Observations and Maintenance Recommendations

Deleterious Modifications & Procedures

1) Many induction unit thermostats have been disabled or are currently inoperative.
2) Some perimeter spaces have no thermostatic control due to space rezoning or new partitions.
3) "Add-on" air conditioning systems patched into existing supply ducts are causing control problems. solution ??
4) Control of makeup air to the Kitchen has been modified; probably due to clogged steam coil unable to heat outside air. solution ??
5) Exhaust systems retrofitted in Kitchen are incorrectly installed.
6) The Kitchen exhaust system operates continuously which compounds the problems associated with item 4. solution
7) Automatic reset schedule of water temperature to perimeter induction units in the original hospital building has been disabled; currently adjusted manually. Chilled water temperature to induction units is too low - causing condensation on coils.
8) Many hospital interior spaces have use definition changed, but terminal units cannot handle the load.
9) ACU-3 has an air cooled refrigeration unit retrofitted to the outside air intake. This system is counterproductive to proper operation of ACU-3. solution
10) Electronic filter system of ACU-4 is turned off. Pan humidifier for Nursery not in use.
11) The drive system on AC-1 in the Clinic addition has been modified to lower the fan RPM from 3800 (design) to 1255. The resulting total static pressure is less than 0.5 inch and the induction units do not operate properly.
12) EF-25 in Clinic Addition is always turned off.
13) ACU-6 serving the hospital X-RAY suite is delivering only 1150 CFM whereas design is 3000 CFM.

Survey Observations

1) Ducts and coils need to be cleaned.
2) Air handling apparatuses need to be cleaned.
3) Dry type filters often found very dirty. If filters are changed/cleaned in accordance with manufacturers instructions, manhours used in cleaning air devices throughout the hospital will be reduced.
4) Some steam traps are non-functional.
5) A 3/4 inch nipple was removed from the steam supply to a sterilizer. The deposits in one end of the nipple reduced the effective pipe area to approximately 5 percent. solution
6) Many control valves are inoperative.
7) Sections of insulation are missing from steam piping in the crawl space.
8) Many light fixture lenses are discolored and/or dirty.
9) Existing cooling tower for hospital chillers is in very bad shape. Recommend replacement.
10) ACU-1 casing and associated ductwork insulated with asbestos materials.
11) Drive system on fan F-1 has high amplitude vibration; need attention.
12) ACU-2 casing and associated ductwork insulated with asbestos materials.
13) Pan under ACU-2 sprayed coil leaks.
14) Flex connection on ACU-3 is leaking.
15) Adhesive wash system on ACU-3 is not functional.
16) Kitchen HVU-1, HVU-2 and HVU-3 in poor condition.
17) Fan in kitchen RV-3 is inoperative; cause unknown.
18) Belts loose on kitchen RV-4 and RV-7. Outside air louver to compressor room blocked.
19) Fan on RV-13 inoperative; cause unknown.
20) Belts on EF-37 of Clinic addition need replaced.

Operational and Maintenance Recommendations

1) Initiate program to perform the following functions on a regularly scheduled basis:
   a) Check belts on fan drives and replace when worn or broken.
   b) Replace filter media at intervals recommended by manufacturer.
   c) Clean coils and air handling apparatuses.
   d) Clean water and steam strainers.
   e) Inspect steam traps and replace when inoperative.
   f) Clean light fixture lenses and replace when discolored.
   g) Repair damaged insulation.
   h) Check all automatic control valves and dampers for proper function.
2) Replace the existing cooling tower for the original hospital chillers.
3) Remove all asbestos insulation materials.
4) Provide necessary system changes in the boiler plant to improve the quality of steam to the hospital and other buildings. Presently the steam is causing rapid buildup of deposits in pipes and coils.
5) Recalibrate fans and balance air delivery systems.
6) Replace damaged or missing insulation of steam pipes.

IV. ENERGY AND COST SAVINGS

Energy consumption without the implementation of energy conservation projects will continue at approximately the level of the baseline energy and use and cost as calculated for a typical year.

Implementation of all recommended energy conservation projects will result in substantial energy savings. Table A-9 is provided showing energy use before and after the implementation of energy conservation projects. Total energy savings are expressed in terms of MBtu (Million Btu), and relative percentages.

Energy consumption is also shown graphically in the form of two bar charts which follow. Energy consumption before and after conservation is presented by building and also by fuel type.

Figure A-4A SOURCE ENERGY CONSUMPTION BY BUILDING

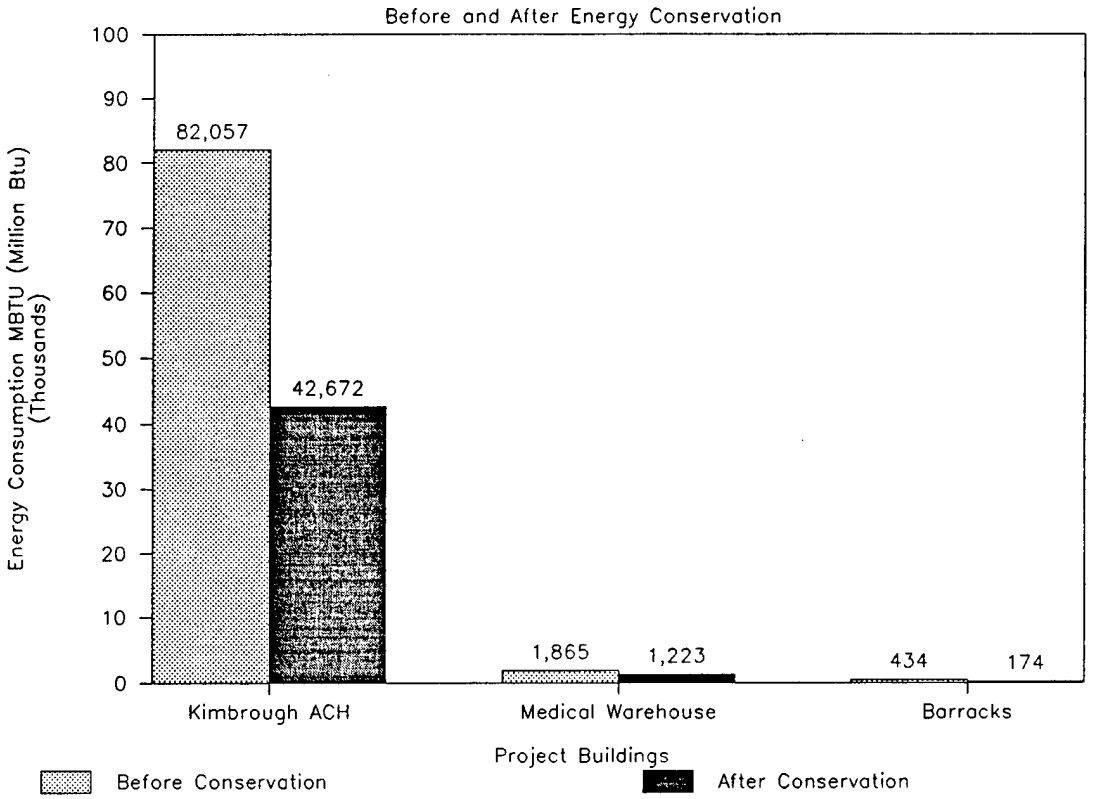


Figure A-4B SOURCE ENERGY CONSUMPTION BY FUEL TYPE

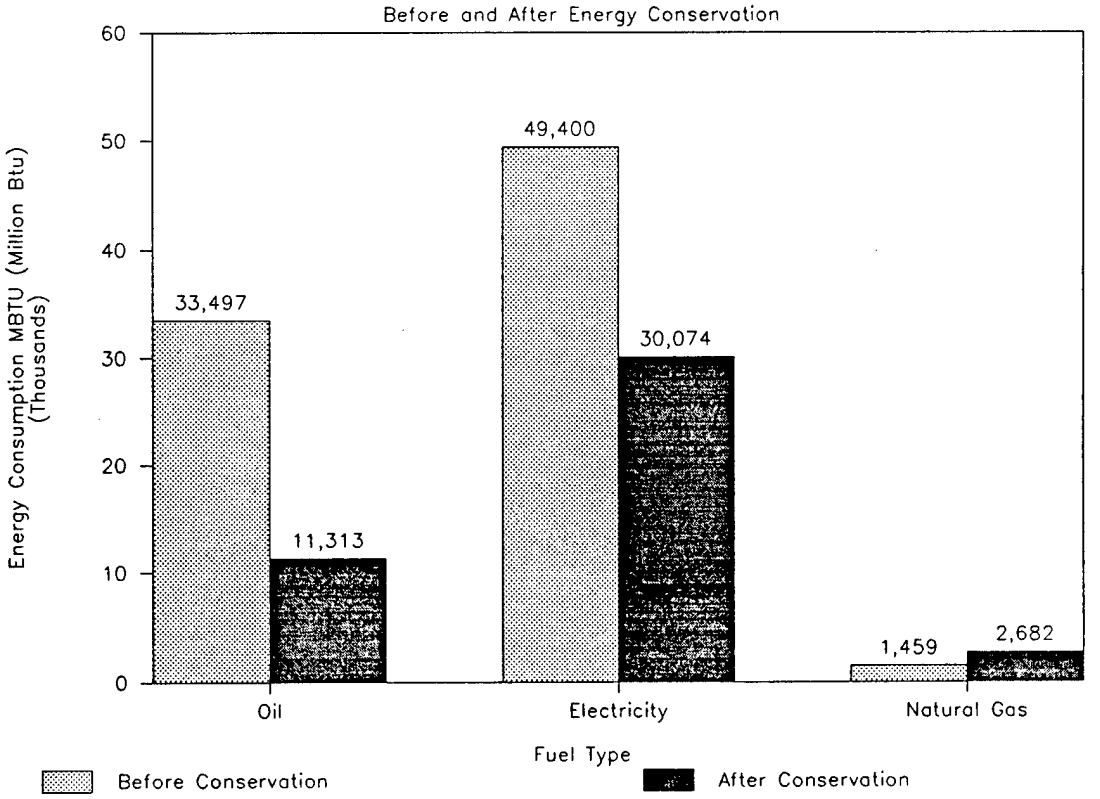


Table A-9

TOTAL POTENTIAL ENERGY CONSUMPTION AND COST SAVINGS

ENERGY CONSUMPTION AND COST BEFORE CONSERVATION

	Fuel Oil	Elec-tricity	Natural Gas	Total
Kimbrough Army Community Hospital	31,215	49,383	1,459	82,057
Medical Warehouse	1,865			1,865
Barracks	417	17		434
Total	33,497	49,400	1,459	84,356
Energy Cost	$198,036	$195,470	$6,170	$399,676

ENERGY CONSUMPTION AND COST AFTER CONSERVATION

Following Implementation of ECIP, QRIP, PECIP-1, PECIP-2 & LC/NC

	Fuel Oil	Elec-tricity	Natural Gas	Total
Kimbrough Army Community Hospital	11,146	30,067	1,459	42,672
Medical Warehouse			1,223	1,223
Barracks	167	7		174
Total	11,313	30,074	2,682	44,069
Energy Cost	$66,881	$119,000	$11,342	$197,223

TOTAL POTENTIAL ENERGY SAVINGS

	Fuel Oil	Elec-tricity	Natural Gas	Total
Savings (MBtu) All Buildings	22,184	19,326	(1,223)	40,287
Precent Energy Savings	66%	39%	-84%	48%
Energy Cost Savings	$131,155	$76,470	($5,172)	$202,453

Notes: Energy costs are expressed in current dollars at current rates.

Fuel oil	$0.8200 / gallon	$5.91 $/MBtu
Electicity	$0.0459 / kWh	$3.96 $/MBtu
Natural Gas	$0.4229 / Therm	$4.23 $/MBtu

V. ENERGY PLAN

The Energy Conservation Opportunities (ECO's) recommended in this report have been classified according to the following program categories: ECIP, QRIP, PECIP, LC/NC. These categories are explained in Volume 2 Section E. Complete program documentation for the projects has been developed and is separately bound in "Volume 3 - Programming Documentation." Total cost and Savings-to-Investment Ratio (SIR) for each component ECO of these developed projects is shown in Table A-10.

A schedule for the funding, design, and construction associated with the recommended measures, was prepared with the guidance of the Army Corp of Engineers and the facility. This schedule is presented in Figure A-5. According to this schedule, construction would be completed and energy/cost savings begin to be realized in Fiscal Year 1990 for all projects with the exception of the ECIP project, which would be completed in Fiscal 1991.

The energy savings to be realized from the combination of ECO's differs from the arithmetic sum of the savings calculated for individual ECO's. The savings due to the synergism of the combined ECO's to be completed in FY 90 and FY 91 is shown in Table A-11 as well as implementation costs, Savings-to-Investment Ratio, and Amortization Period. The effect of project implementation on energy consumption for the period FY 89 through FY 94 is shown graphically in Figure A-6.

Energy cost projections are presented for FY86 through FY 94 for electricity, distillate fuel oil and natural gas. Baseline energy costs were calculated using reported actual facility energy rates. Projected costs for FY87-94 were calculated using fuel cost escalator rates taken for FY87-94 from NBS-135. Energy cost data is shown in Figure A-7 and Table A-12.

Table A-10

PROJECT DEVELOPMENT: SUMMARY OF DEVELOPED PROJECTS

ECO #	Description	Instal. Cost ($)	Energy Savings (MBtu)	Economic Life (yrs)	Annual Savings ($) (1)	SIR	Amort. Period (yrs) (2)
ECIP: ENERGY CONSERVATION INVESTMENT PROGRAM							
10	Dual Duct VAV in Hospital Addition	$251,000	7,761	15	$30,138	1.33	8.38
	PACKAGE TOTAL (NOTE 3.)	$251,000	7,761	15	$30,138	1.33	8.38
QRIP: QUICK RETURN ON INVESTMENT PROGRAM							
5	Unocc.Mode on C-Wing Air Systems	$34,500	1,979	15	$9,269	2.91	3.75
9	Night-Cycle-On ACU1-M	$2,220	2,849	15	$15,153	78.40	0.15
15	Unoccupied Mode at ACU1-A	$14,300	1,279	15	$6,316	4.86	2.28
23	Programmable Timer On Kit. Ventil'n	$2,800	2,094	15	$10,846	43.93	0.26
25	Night Cycle on ACU4-M	$1,800	1,720	15	$9,377	60.72	0.19
26	Night Cycle on ACU3-M	$8,900	1,504	15	$8,444	10.99	1.08
31	Night Cycle For ACU2-A AND ACU3-A	$24,500	4,709	15	$23,463	10.58	1.05
	PACKAGE TOTAL (NOTE 3.)	$89,020	15,375	15	$79,725	10.18	1.12
PECIP-1: PRODUCTIVITY ENHANCING CAPITAL INVESTMENT PROGRAM (Package 1)							
3	O/A Unit to Serve Dining Hall	$23,800	992	15	$4,619	2.32	5.19
12	Variable-Flow Primary CHW Pumps	$27,900	910	25	$2,991	1.33	9.39
14	Kitchen Ventilation Improvements	$61,500	4,729	25	$27,065	8.04	2.29
17	Exhaust Heat Recovery On ACU2-M	$32,400	1,238	25	$6,774	4.35	4.81
22	O/A Make-Up At Steam P.R.Station	$3,100	1,932	15	$11,118	42.89	0.28
28	Insulation of Steam P.R. Station	$1,540	451	25	$2,642	31.57	0.59
	PACKAGE TOTAL (NOTE 3.)	$153,817	10,252	25	$55,221	6.53	2.80
PECIP-2: PRODUCTIVITY ENHANCING CAPITAL INVESTMENT PROGRAM (Package 2)							
11	Interconnect All Chillers	$52,800	4,804	25	$18,366	2.89	4.26
37	Insulate Barracks Walls	$15,900	260	25	$1,518	1.73	10.55
	PACKAGE TOTAL (NOTE 3.)	$68,023	5,064	25	$19,885	3.44	3.71
LOW COST / NO COST MODIFICATIONS							
18	Relamp W/Energy Efficient Lighting	$8.94	0.8	25	$12.92	16.29	0.70
20	Eliminate Publication Room Exhaust	$25	183	n/a	$922	596.56	0.03
21	Control Valve At Dish Drying Coil	$924	446	25	$2,659	52.54	0.35
24	Gas-Fired IR Htg. For Medical Whse.	$26,000	463	15	$4,544	2.19	5.76
36	Upgrade Hospital Roof Insulation	$56,047	1,781	25	$10,261	3.30	5.50
40	Tower Multi-Speed Fan ($ Increment)	$3,600	93	25	$312	1.08	11.62
	PACKAGE TOTAL (NOTE 3&4) Approximate	$86,605	2,966		$18,710		4.66
TOTAL FOR ALL PROJECTS (5)		$648,465	40,287		$200,000 Approx.		

NOTES:(1) ECIP LCCA Item 4: First year dollar savings
(Negative savings indicate yearly cost)

(2) Simple payback period

(3) Package totals are the resulting totals considering synergistic effects if any. Totals may not be the algebraic sum of component projects.

(4) Low Cost No Cost Modifications are not funded as one package.

(5) Resulting figures consider synergism and may not be the algebraic sum of individual projects.

Figure A-5

ENERGY CONSERVATION PROJECT IMPLEMENTATION SCHEDULE

	FISCAL YEAR 87	88	89	90	91	92	93
	CALENDAR YEAR 87	88	89	90	91	92	
FINAL REPORT		****					
FUNDING ACQUISITION		**********					
DESIGN							
QRIP			*******				
PECIP-1			*******				
PECIP-2			*******				
LC/NC			*******				
ECIP				*********			
CONSTRUCTION							
QRIP			**				
PECIP-1			****	****			
PECIP-2			****	**********			
LC/NC			****	**			
ECIP					**********		

This schedule is based on project criteria effective at the time project analyses were preformed. Revisions may be required by the user to reflect current funding requirements.

TABLE A-11

PROJECTS IMPLEMENTED BY FISCAL YEAR 1990

Description	Instal. Cost ($)	Energy Savings (MBtu)	Economic Life (yrs)	Annual Savings ($) (1)	SIR	Amort. Period (yrs) (2)	Remarks
QRIP : QUICK RETURN ON INVESTMENT PROGRAM	$89,020	15,375	15	$79,725	10.18	1.12	$89,596
PECIP-1: PRODUCTIVITY ENHANCING CAPITAL INVESTMENT PROGRAM (Package 1)	$153,817	10,252	25	$55,221	6.53	2.80	$154,812
PECIP-2: PRODUCTIVITY ENHANCING CAPITAL INVESTMENT PROGRAM (Package 2)	$68,023	5,064	25	$19,885	3.44	3.71	$68,463
LC/NC : LOW COST / NO COST MODIFICATIONS	$86,605	2,966		$18,710		4.66	
COMBINED PROJECTS	$397,465	35,589					

PROJECTS IMPLEMENTED BY FISCAL YEAR 1991

Description	Instal. Cost ($)	Energy Savings (MBtu)	Economic Life (yrs)	Annual Savings ($) (1)	SIR	Amort. Period (yrs) (2)	Remarks
ECIP : ENERGY CONSERVATION INVESTMENT PROGRAM	$251,000	7,761	15	$30,138	1.33	8.38	$252,624
QRIP : QUICK RETURN ON INVESTMENT PROGRAM	$89,020	15,375	15	$79,725	10.18	1.12	$89,596
PECIP-1: PRODUCTIVITY ENHANCING CAPITAL INVESTMENT PROGRAM (Package 1)	$153,817	10,252	25	$55,221	6.53	2.80	$154,812
PECIP-2: PRODUCTIVITY ENHANCING CAPITAL INVESTMENT PROGRAM (Package 2)	$68,023	5,064	25	$19,885	3.44	3.71	$68,463
LC/NC : LOW COST / NO COST MODIFICATIONS	$86,605	2,966		$18,710		4.66	
COMBINED PROJECTS	$648,465	40,287					

NOTES:(1) ECIP LCCA Item 4: First year dollar savings
(Negative savings indicate yearly cost)
(2) Simple payback period

Figure A-6 PROJECTED ENERGY CONSUMPTION

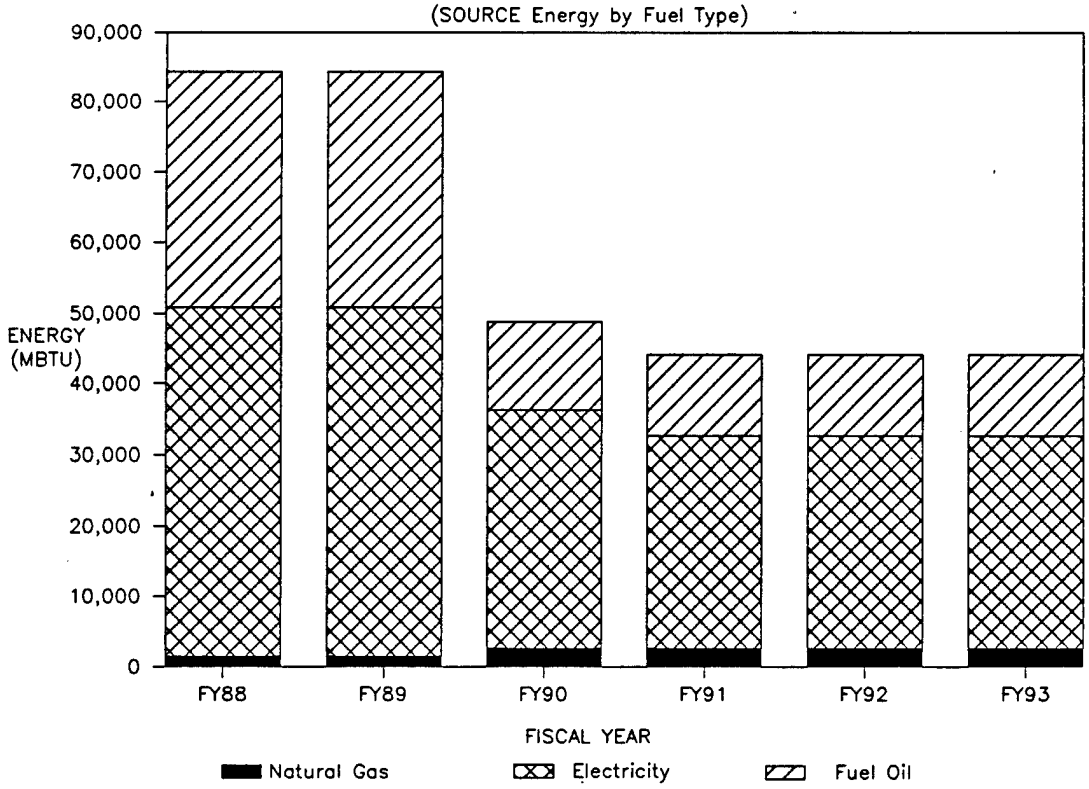


Figure A-7 PROJECTED ANNUAL FUEL COSTS

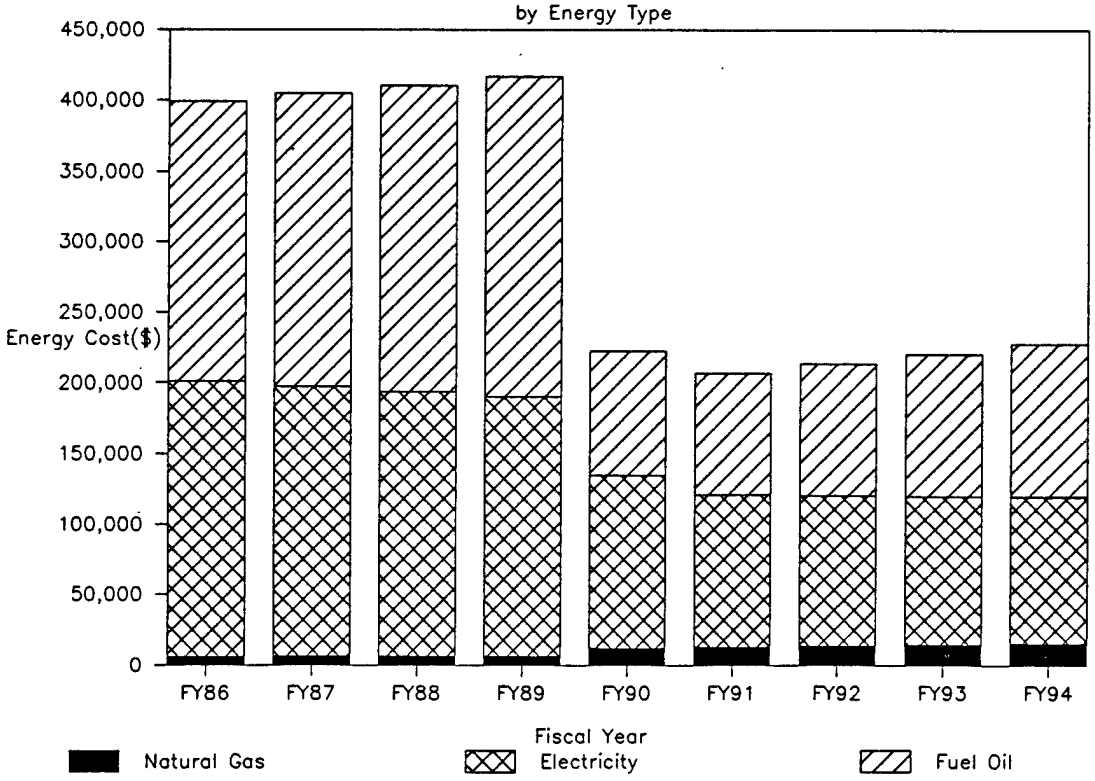


Table A-12 ENERGY COST PROJECTIONS FY86 through FY94

	Electricity				Distillate Oil				Natural Gas				
	Source (MBtu) (1)	Esc. Rate (2)	Fuel Rate $/MBtu (3)	Energy Cost	Source (MBtu)	Esc. Rate	Fuel Rate $/MBtu	Energy Cost	Source (MBtu)	Esc. Rate	Fuel Rate $/MBtu	Energy Cost	Energy Cost
FY86 Baseline	49,400		$3.957	$195,471	33,497		$5.912	$198,036	1,459		$4.229	$6,170	$399,676
FY87 Before conservation	49,400	-2.02%	$3.877	$191,522	33,497	4.54%	$6.180	$207,026	1,459	2.34%	$4.328	$6,314	$404,863
FY88 Before conservation	49,400	-2.02%	$3.799	$187,653	33,497	4.54%	$6.461	$216,425	1,459	2.34%	$4.429	$6,462	$410,541
FY89 Before conservation	49,400	-2.02%	$3.722	$183,863	33,497	4.54%	$6.754	$226,251	1,459	2.34%	$4.533	$6,613	$416,727
FY90 After Conservation (4)	33,661	-2.02%	$3.647	$122,753	12,424	4.54%	$7.061	$87,726	2,682	2.34%	$4.639	$12,442	$222,921
FY91 After Conservation (5)	30,074	-1.24%	$3.602	$108,312	11,313	7.76%	$7.609	$86,080	2,682	6.35%	$4.934	$13,232	$207,624
FY92 After Conservation (5)	30,074	-1.24%	$3.557	$106,969	11,313	7.76%	$8.199	$92,760	2,682	6.35%	$5.247	$14,072	$213,801
FY93 After Conservation (5)	30,074	-1.24%	$3.513	$105,643	11,313	7.76%	$8.836	$99,958	2,682	6.35%	$5.580	$14,965	$220,566
FY94 After Conservation (5)	30,074	-1.24%	$3.469	$104,333	11,313	7.76%	$9.521	$107,715	2,682	6.35%	$5.934	$15,916	$227,963

1. Project energy consumption based on energy savings calculations.
2. Energy cost escalation rates based on projections from NBS-135, for Region 3. (Industrial)
   Electric FY87-90 (-2.02%), FY90-95 (-1.24%)
   Distillate FY87-90 (4.54%), FY90-95 (7.76%)
   Natural Gas FY87-90 (2.34%), FY90-95 (6.35%)
3. Fuel rates as used for the 1986 baseline are based on base reported utility records.
4. Reduced energy consumption for FY 90 is based on the assumed implementation of QRIP, PECIP-1, PECIP-2, and LC/NC projects.
5. Reduced energy consumption for FY 91 and following years is based on the assumed implementation of ECIP, QRIP, PECIP-1, PECIP-2, and LC/NC projects.

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